Prince George Forest Region

Forest Resources & Practices Team

March 1997
Note #PG-11

FOREST RESEARCH NOTE

Operational considerations for underplanting hardwood stands with white spruce

by Craig DeLong, Landscape Ecologist

Purpose

The purpose of this research extension note is to provide practitioners with information to assist them to:

- choose the most appropriate sites for planting white spruce under hardwood canopies.
- develop a silviculture prescription for white spruce plantations under hardwood canopies.

Background

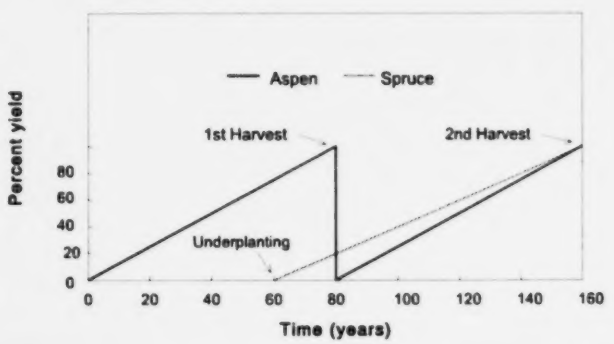
There is extreme pressure on the forested land base in the Canadian boreal forest to produce conifer and hardwood products, and at the same time to provide areas for agriculture, range, recreation, and wildlife. These competing interests on the land base, along with some difficulties with white spruce regeneration after clearcutting, and public demands for more ecologically based management, has led to the demand for better silvicultural systems for mixedwood stands (Lieffers and Beck 1994). To meet this challenge, harvesting techniques have been developed to protect the white spruce understory while harvesting the aspen overstory (Brace 1991; Sauder 1992). New harvesting and tending models for managing boreal mixedwood stands have been suggested (Navratil 1996; Tanner *et. al.*. 1996).

Historically, mixed stands of hardwood and conifer species, especially aspen (*Populus tremuloides*) and white spruce (*Picea glauca*) were very common throughout the boreal forest (Rowe 1972). However, human settlements and repeated disturbances related to forestry, agriculture or range management, have removed the spruce seed source and created pure hardwood stands. Underplanting these hardwood stands with white spruce may generate stands similar to natural mixedwood stands. This may also provide an alternative to clearcutting and single species management.

Planting spruce under hardwood canopies has the potential to:

- reduce overwinter injury to white spruce by maintaining snow cover over seedlings (Krasowski 1996).
- reduce summer frost damage to seedlings by moderating night time minimum temperatures (Stathers 1989).
- reduce white pine weevil damage to white spruce by having overhead shading (Taylor *et. al.* 1996).
- reduce white spruce root rot infestations by allowing a fallow period of resistant hardwood species before the spruce becomes re-established. (pers. comm. Richard Reich, Regional Pathologist, Prince George MoF).
- provide thermal cover for ungulates as the spruce become larger.
- improve visual quality by continual maintenance of tree cover.

FIGURE 1. Schematic showing the proposed management regime for spruce planted under pure aspen stands.



Unpublished results from an underplanting trial near Dawson Creek indicate that spruce seedlings planted under an aspen canopy suffered less frost damage, were less chlorotic and reached equivalent height growth after four growing seasons, compared to seedlings planted in ecologically similar clearcuts. Survival of underplanted trees exceeded 95% and height growth was acceptable (e.g., 7 cm average height increment). Recent stem analysis works indicates that height growth of spruce under an aspen overstory will be similar to the growth in a clearcut, once the trees grow above the height of the dominant understory vegetation (i.e., 70 cm) (Lieffers *et. al.* 1996a).

Since the normal commercial rotation ages for hardwood species and white spruce differ by approximately 40 years (i.e., 60 for aspen vs. 100 for white spruce), multiple entry harvesting and tending models for mixedwood stands have been recommended (Brace and Bella 1988; Tanner *et. al.* 1996) (Figure 1). These models assume that spruce will become established at least 20 years after the hardwood species. The hardwood stems are harvested at 60-80 years of age while the understory spruce is protected. Finally, 60 to 80 years, later the resultant spruce stand is harvested. Options available following the spruce harvest include: promoting a pure hardwood stand; promoting a mixedwood stand; or promoting a pure white spruce stand. Final choice would depend on factors such as the vigour of the hardwood component at time of harvest and the current or projected demand for wood products.

TABLE 1. Summary of relative ratings of risk to spruce crop and operational barriers associated with underplanting hardwood stands of different ages.

Risk or Operational Barrier	Age of Hardwood Stand (years)		
	0-30	31-60	>60
Overstory competition	High[1]	Moderate	Moderate
Understory competition	High-Low[2]	Moderate	High
Hare/Vole damage	High	Moderate	High
Windthrow after harvest	High-Moderate	Moderate	Low
Damage during overstory removal	High-Moderate	Moderate	Low-Moderate[3]
Overtopping by aspen after overstory removal	Low	Moderate	High-Moderate
Planter accessibility	Low[1]	Moderate-High	High-Moderate
Availability of suitable microsites	Low	Moderate	High

1 *assumes no thinning treatment.*
2 *high prior to hardwood stand closure but reduces significantly after stand closure.*
3 *low if stems large enough so that they are easily visible to harvesting equipment operator.*

Site Selection

The choice of sites for underplanting depends upon many factors such as stand level objectives, desired silvicultural system, and stand availability. Hardwood stands of any age can be underplanted but there are some risks or operational barriers for underplanting stands of certain ages that must be considered (Table 1). A good summary of silvicultural system options and ways to reduce certain risks is contained in Leiffers *et. al.* (1996b). Thirty to 60 year old stands seem to be the most appropriate for underplanting. This is based on the assumptions that 1) stands less than 30 years old have not undergone complete self thinning and so they will be more expensive to plant due to thinning costs and poor planter access and 2) for stands greater than 60 years old, insufficient time would elapse for adequate spruce height growth between planting and the desirable harvesting age of the overstory (i.e., 60-80 years). The second assumption is based on a summary of the literature by Johnson (1986) which suggests spruce be at least 2.5 metres in height before an aspen overstory is removed. This reduces the chance of aspen suckers competing aggressively with the planted spruce.

Previous research of the light regime under hardwood canopies indicates a strong relationship between the light available for photosynthesis and stand basal area and density (Figure 2). Stands with the lowest basal area and density provide the best light conditions for white spruce development. However, the increased light conditions under open canopies also increases the amount of shrub and herb cover (DeLong and Tanner, unpublished data) so some level of brushing may be required under very open stands. It is recommended that the most suitable stands for underplanting based on light regime are those with a density of less than 1200 sph (stems per hectare) and basal area less than 35 m^2/ha.

Although adequate soil moisture is important for the establishment and growth of white spruce, it also increases the understory competition particularly from bluejoint (*Calamagrostis canadensis*). Underplanting trials were carried out near Dawson Creek in the moist warm Boreal White and Black Spruce (BWBSmw) biogeoclimatic unit, which has a mean annual precipitation of 485 mm and a mean May - September precipitation of 290 mm. In those trials, survival was higher on average to moderately dry (i.e., mesic - submesic) than on wetter sites (i.e., subygric - hygric).

Slopes with good air drainage and where frost will not pond, are generally the most suitable for white spruce establishment. However, due to the ameliorating influence of an overstory canopy, underplanting hardwood stands can provide a viable option for establish-

ing white spruce in sites which are otherwise inappropriate due to a high risk of frost damage.

Suitability of the site for hardwood overstory removal while protecting the understory, is another important consideration when choosing a site for underplanting. For example, available harvesting technology may limit the success of overstory removal on steeper slopes. Previous studies have indicated that there will be increased damage to the understory spruce on sites with a high wind throw hazard, such as sites with shallow or poorly-drained soils (Brace 1992). Consequently, these sites should receive a lower priority for underplanting.

Although maturing aspen stands are not preferred habitat for snowshoe hares, these animals caused extensive damage to underplanted spruce, where spruce were planted along bladed trails in 80 to 100 year old aspen stands (unpublished data, Forestry Canada Project A.83). However, these older stands are generally open and have higher browse availability than stands within the recommended 30 to 60 year old range. In addition, the blading treatment may have increased rabbit damage. It is advisable to avoid underplanting stands which are in close proximity to recently disturbed areas since they are prime rabbit feeding habitat. Other suggestions for reducing hare damage are reducing understory vegetation, planting larger seedlings, use of chemical or physical barriers and population control (Radvanyi 1987).

Stand Establishment

It is assumed that a silviculture prescription will be conducted before underplanting is conducted, as required by law. The following information will assist in preparing the prescription, based on information from previous operational and research experience.

Based on the trials to date, the successful establishment of white spruce under hardwood canopies is relatively simple and inexpensive. No differences in survival or growth were found between various shade adapted stock and normal 2-0 operational stock 2 years after planting (unpublished data, Ministry of Forests Experimental Project 1114). Results of the same study also indicated there was no measurable advantage of planting on microsites prepared with a Hawke hand-held scarifier over raw planting. On sites with a well developed shrub layer, brushing of planting trails will improve planter efficiency and may improve seedling growth. This benefit should be weighed against the extra costs of the brushing.

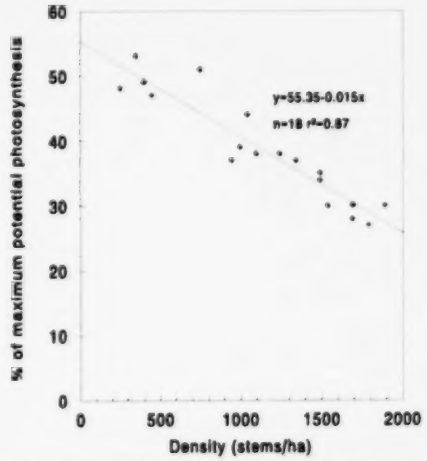
Recommended planting density is 1400 - 1800 sph to ensure adequate stocking following the hardwood overstory harvest. This should result in a fully stocked spruce stand despite anticipated losses due to pests, environmental extremes, physical damage during harvesting, and wind throw. To ensure that obligations are met, contact the nearest Ministry of Forests office for the most up to date stocking standards for mixedwood stands.

Seedlings should be planted as early as possible in spring, to take advantage of early season moisture and higher light levels prior to full leaf emergence of deciduous species. After full leaf emergence of the aspen canopy, moisture levels drop significantly due to the relatively high moisture demand of this canopy. Thus, planting should be avoided after abnormally dry winters or during abnormally dry spring conditions to reduce the potential for drought induced seedling losses.

Planters should be instructed to avoid planting close (< 1m) to live dominant hardwood stems, to reduce the potential damage to the established spruce during hardwood overstory removal. Another consideration is to layout all hauling and skidding roads prior to planting to reduce unnecessary spruce stock loss during overstory harvesting. If located before planting, these roads will be easy to find prior to harvest due to the absence of spruce stems along them.

Although vegetation competition is much less aggressive under a canopy than in a cleared area, there may be need for brushing and weeding during spruce establishment. As previously mentioned, vegetation competition from species like bluejoint can be high on wetter than average sites. Chemical treatment using a backpack sprayer has been found to be an effective control of understory vegetation under hardwood stands (pers. comm. Phil Lepage, Research Silviculturist, Prince Rupert MoF). Mechanical brushing also seems to be more effective under a hardwood overstory than in cleared areas, due to the lack of resources (e.g., light) for rapid recovery of the competing species (DeLong, unpublished data).

FIGURE 2. Regression demonstrating the percentage of available light throughout an entire growing season, as a function of density of aspen.



Summary

Site Selection

Ideal hardwood stands for underplanting have the following characteristics:

- 30-60 years old;
- densities <1200 sph and basal areas <35m²/ha;
- average to moderately dry (submesic-mesic) moisture regime;
- sites where overstory can be removed with minimal damage to understory;
- sites with low to moderate wind throw hazard;
- sites not in close proximity to clearings which will attract snowshoe hares.

Stand Establishment

Recommendations for planting and stand tending are as follows:

- plant large caliper stock at densities between 1400 and 1800 sph;
- plant as early as possible in spring, prior to full leaf development of deciduous competitors;
- boot screef and plant in humus, well rotted wood or mineral soil;
- prepare planting trails with brush saws if there is a well developed shrub layer;
- if high competition is expected, then prepare the site manually or chemically prior to planting in early June.

For further information

Craig DeLong - Landscape Ecologist
BC Ministry of Forest, Prince George Region
1011 - 4th Avenue, Prince George, BC, V2L 3H9
Phone (250) 565-6202 Fax (250) 565-4349
email: sdelong@mforØ1.for.gov.bc.ca

Literature Cited

Brace Forest Services. 1992. Protecting white spruce understories when harvesting aspen. For. Can. and For. Lands Wildl., Alta. For. Serv. Edmonton, Alta. Canada-Alberta-Parnership Agreement in For. Rep. No. 102. Prog. Rep.

Brace, L.G. and I.E. Bella. 1988. Understanding the understory: dilemma and opportunity. *In* R.D. Adams (ed.) Aspen Symposium '89. Proc. Symp. July 25-27, 1989, Duluth, Minn. USDA. For. Serv. Gen. Tech. Rep. NC-140. pp. 69-86.

Johnson, H.J. 1986. The release of white spruce from trembling aspen overstoreys. A review of available information and silvicultural guidelines. Prepared for Man. Dep. of Nat. Res., For. Branch by Johnson Forestry Services. 109p.

Krawsowski, M. 1996. Measures to reduce overwinter injury to planted spruce in the boreal forest of British Columbia. For. Can. and B.C. Min. For., Victoria, B.C. FRDA Rep. No. 254.

Lieffers, V.J. and J.A. Beck, Jr. 1994. A semi-natural approach to mixedwood management in the prairie provinces. For. Chron. **70**:260-264.

Lieffers, V.J., K.J. Stadt, and S. Navratil. 1996a. Age structure and growth of understory white spruce under aspen. Can. J. For. Res. **26**:1002-1007.

Lieffers, V.J., R.B. Macmillian, D. MacPherson, K. Branter, and J.D. Stewart. 1996b. Semii-natural and intensive silvicultural systems for the borcals mixedwood forest. For. Chron. **72**:286-292.

Navratil, S. 1996. Silvilcultural systems for managing deciduous and mixedwood stands with white spruce understory *In:* Comeau, P.G. and K.D. Thomas (eds.) Silvilculture of temperate and boreal hardwood-conifer mixtures. B.C. Min. For., Victoria, B.C., Land Manage. Handb. No. 36.

Randvanyi, A.. 1987. Snowshoe hares and forest plantations: a literature review and problem analysis. For. Can. Edmonton, Alta. Info. Rep. Nor-X-290.

Rowe, S. 1972. Forest Regions of Canada. Dept. of Environment, Can. For. Serv. Pub. 1300.

Sauder, E.A. 1992. Timber-harvesting techniques that protect conifer understory in mixedwood stands: case studies. For. Can. and For. Lands Wildl. Alta. For. Serv. Edmonton, Alta. Canada-Alberta Partnership Agreement in For. Rep. No. 101.

Stathers R.J. 1989. Summer frost in young forest plantations. For. Can. and B.C. Min. For., Victoria, B.C. FRDA Rep. No. 73.

Tanner, D., S.C. DeLong, and A. Eastham. 1996. Investigations of planting white spruce under a trembling aspen canopy. *In:* Comeau, P.G. and K.D. Thomas (eds.) Silvilculture of temperate and boreal hardwood-conifer mixtures. B.C. Min. For., Victoria, B.C., Land Manage. Handb. No. 36.

Taylor, S. P., R.I. Alfaro, C. DeLong, and L. Rankin. 1996. The effects of overstory shading on white pine weevil damage to white spruce and its effect on spruce growth rates. Can. J. For. Res. 26:306-312.